E-LEARNING IN SCIENCE AND TECHNOLOGY VIA A COMMON LEARNING PLATFORM IN A LIFELONG LEARNING PROJECT

Freddy Priem [freddy.priem@khbo.be]
Johan Calu [johan.calu@khbo.be]
Renaat De Craemer [renaat.decraemer@khbo.be]
Katholieke Hogeschool Brugge-Oostende, Belgium [http://www.khbo.be]

Fran Pedreschi [fran.pedreschi@dit.ie]
Dublin Institute of Technology, Dublin, Ireland [http://www.dit.ie]

Thomas Zimmer [thomas.zimmer@iut.u-bordeaux1.fr]
Sylvain Saïghi [sylvain.saighi@ims-bordeaux.fr]
Université de Bordeaux 1, Bordeaux, France [http://www.iut.u-bordeaux1.fr]

Jarmo Lilja [jarmo.lilja@tamk.fi]
Tampereen Ammattikorkeakoulu, Tampere, Finland [http://www.tamk.fi]

Abstract:

This three-year Virtual Measurements Environment curriculum development project for higher education within the Lifelong Learning Programme of the European Union is the result of intense collaboration among four institutions, teaching applied sciences and technology. It aims to apply the principles and possibilities of evolved distance and e-learning in originally traditional course materials and laboratory experiments during all the stages of the learning and assimilating process. One of the challenges for the consortium was the use of a common electronic learning platform. By filling in questionnaires the students at the partner institutions could contribute to the usefulness of the developed outcomes. Some students even volunteered to go abroad to a partner institution for a short time to execute and evaluate some tasks and laboratory experiments, and thus creating added value to the e-learning possibilities.

The project outcomes are diverse, ranging from physics to electronics. Subsequently, they can be integrated into a broad spectrum of topics. When taking all the developed modules and laboratory experiments the student is awarded a maximum of 20 ECTS credits.

On the whole, this Erasmus project was fascinating not in the least because of the possibilities of the blended problem-based learning model and the difficulties raised by the common electronic learning platform – both technically and pedagogically.

Key-words:

distance learning, blended problem-based learning, electronic learning platform, remote measurement, virtual laboratory experiment, international co-operation, student mobility

List of Topics

1. Introduction
2. Preliminary considerations
3. Background of the project and course modules
4. The VME-project: objectives and methodology
5. The course module on Vacuum Science and Techniques for Nanoscience
6. The course module on Electronics of Devices and Circuits
7. The course module on the Measurement of the Hall Effect
8. The course module on Monitoring of Environment and Industrial Drive Systems
9. Project guidelines and results of the questionnaires
10. Conclusions

11. References

1. Introduction

In 2004 the European Open and Distance Learning Liaison Committee delivered a **policy paper** *"Distance Learning and eLearning in European Policy and Practice: The Vision and the Reality"* to European and national policy makers in charge of learning innovation [LC 2004]. This paper produced a certain impact on the European Commission's actions and initiatives. On 3 May 2006 followed the second policy paper *"Learning Innovation for the Adapted Lisbon Agenda*" [LC 2006]. It demanded attention to the need of co-ordination among EC services, on the opportunity to connect the Lifelong Learning agenda and eLearning developments, and on the opportunity to consult more systematically the relevant professional networks and stakeholders on new policy developments. As the discussions on eLearning and ICT for learning had flared up, the required learning innovation was bound to emerge.
Two recommendations for urgent action and for systematic innovation and support are of some importance for any future European project in higher education: it should create flexible and distance learning and technology supported learning, and develop a culture of innovation in all education and training activities [LC 2006, 7-8]. The European Commission in the person of Maruja Gutiérrez Diaz, by the end of the same year the European Commission launched the Lifelong Learning Programme (2007-2013), including fundings for a.o. innovative Socrates projects for higher education.

2. Preliminary considerations

According to Szucs, **distance learning** has always been characterised by creativity on the part of the educators and administrators who provide distance study programmes, characterised by access, choice and flexibility options for students [Szucs 2009, 1]. Szucs notes in passing that the EU Minerva Programme in the late nineties of the preceding century recommended the "critical and responsible use of technologies" regarding the use of new ICT tools in distance learning. He also remarks that the traditional paper-based distance education has almost disappeared, in favour of the electronic distance education. Regarding virtual mobility, Szucs notices that it "would form part of the greater transformation of higher education, becoming more inclusive, more international and more flexible" [Szucs 2009, 1]. Evolved distance learning/e-learning "is now certainly presenting itself as a distinct, autonomous, multidimensional professional discipline and resource of coherent experience, increasingly producing and demonstrating its values, integrating theoretical aspects and system approach with valuable practical experience, strategy issues, implementation and management solutions" [LC 2004,3].

According to Curran [Curran 2004], **e-learning strategies** adopted by universities have been approaching the core issue from the perspective of three common objectives:
(1) widening access to educational opportunity,
(2) enhancing the quality of learning,
(3) reducing the cost of higher education.

According to Szucs [Szucs 2009, 2-4] **ICT-supported learning** "was welcomed by higher education institutions as a strong modernisation message. Education policy-makers liked it because of the progressive perspectives and assumed transformation potential". But he also concludes that "in the meantime, the development of pedagogy and methodology and course development issues lagged behind considerably". It is generally acknowledged that "user habits and distance learner profiles are changing significantly, with high expectation for management". He underlines that at undergraduate level ICT-supported solutions are largely supplementary to classroom teaching. And he adds that "ICT is primarily used to support existing teaching structures and traditional ways of tuition". E-learning places an emphasis on enhancing active learning and teaching, small-group teaching, and collaborative work.

The introduction of digital technologies with the Internet connectivity caused a "new" way of teaching, learning and assimilating knowledge. It goes without saying that the student needs more than a PC/laptop and the access to an electronic learning platform: there is "the urgent need to create adequate professional and technological methods, quality and organisational standards" [Donnelly 2009, 5].

The term **blended learning** is used to represent the awareness of the need to design learning systems which are able to integrate at best different learning strategies including ICT-supported learning [LC 2004,2]. Blended learning is "mixed learning" including face-to-face classroom learning, distance and live e-learning, and self-paced instruction. **Problem-based learning** (PBL) uses a student-centred pedagogy, focusses on online problem-solving skills and aims to stimulate the learners' autonomy and responsibility for learning [Donnelly 2009, 2].

3. Background of the project and course modules

In the field of applied science and technology lectures, laboratory practices, experiments and course materials almost automatically imply the pressing need for up-to-date methodical approaches and pedagogical innovations. A lot of innovative and rather new tools are likely to be used, new didactical approaches and strategies are to be put into practice, and teaching staff as well as students should be made familiar with the possibilities of:

(1) open and distance learning, electronic platforms,
(2) online presentation of courses and test materials,
(3) interaction between teacher and student or student and student,
(4) virtual measurements in laboratory sessions, and
(5) evaluation of the students' progress and examination via the electronic learning platforms [Priem 2009, 142].

Consequently, considering the challenges by the Lisbon strategies regarding pedagogical and didactic innovations in the domains of problem-based, blended, open, distance learning, e-learning and appropriate evaluation design on the one side, and the experiences of the close and year-long collaboration with three European institutions of higher education on the other hand, the Katholieke Hogeschool Brugge-Oostende (Catholic University College Bruges-Ostend) took the initiative to apply for the **Virtual Measurements Environment project (VME)**, a Socrates joint curriculum development project of the EU Lifelong Learning Programme [VME].

The ***Dublin Institute of Technology*** in Dublin-Ireland (DIT-IE), the ***Institut Universitaire de Technologie de l'Université de Bordeaux 1*** in Bordeaux-France (IUT/B1-FR), the ***Tampereen Ammattikorkeakoulu*** in Tampere-Finland (TAMK-FI), form part of the consortium with the ***Katholieke Hogeschool Brugge-Oostende*** in Oostende-Belgium (KHBO-BE) as project co-ordinator.

The collaboration of these four partners is rather evident, because of:

(1) their Erasmus bilateral agreements on student and teacher mobility,
(2) the familiarity with the different study programmes and curricula,
(3) the diverse pedagogical and didactic approaches,
(4) the need of familiarity with evolved distance and e-learning, the possibilities of electronic learning platforms, and finally
(5) the desirability of integrating complementary course modules into each other's curricula.

4. The VME-project: objectives and methodology

This three-year project aims to apply the principles and possibilities of distance and e-learning in traditional course materials and laboratory sessions. The use of the computer as virtual measurement instrument in the laboratory is included. The course materials would be made available via Toledo - which is the Blackboard learning platform used at the KULeuven Association - the common electronic learning platform of the VME project [Toledo]. The learning platform offers the course participants two-way electronic communication opportunities.

The VME project focusses on course modules in which students are:

(1) introduced to new scientific and technical developments,
(2) instructed how to use a (virtual) laboratory measurement system,
(3) made familiar with ways of interpreting and evaluating the outcomes of measurements, and
(4) are shown how to submit the outcomes of the measurements for validation.

The pedagogical model of the project is based on four cornerstones, which can be realized via a common electronic learning platform:

(1) student-centred learning,
(2) flexibility,
(3) interaction,
(4) digital inclusion, aligned with the key-competences required for learners in our knowledge-based society.

It was assumed that this common electronic learning platform would be used in all the stages of teaching, learning and managing. The starting-point and pedagogical approach is blended learning. This is considered as a “mixed learning”, including face-to-face classroom learning, distance and live e-learning, and self-paced instruction. It was also acknowledged that user habits and distance learner profiles are changing significantly [Szucs 2009, 3].

The transformative potential of blended PBL is based upon Mezirow’s [Mezirow 1975, 1995] framework of stages leading to transformation:

(1) activating events,
(2) the identification and articulation of underlying current assumptions,
(3) critical self-reflection,
(4) critical discourse,
(5) opportunities to test and apply new knowledge and perspective [Donnelly 2009, 18].

The course structure follows the old adage of learning by doing ("I hear and I forget - I see and I remember - I do and I understand"). According to Kolb’s model [Kolb 1984] - shown in Figure 1 - learning occurs through a sequence of phases where concrete experiences generate an opportunity for observation and reflection. This, in turn, leads to the creation of new concepts and models that are then tested in novel situations. According to Kolb, learners need four different types of skills to make the learning cycle effective. They have to be able to (1) engage openly and without prejudgment in new experiences, (2) reflect and observe their experiences from many perspectives, (3) create concepts that integrate observations into logically sound theories, and, finally, (4) use these theories in decision-making and problem solving.

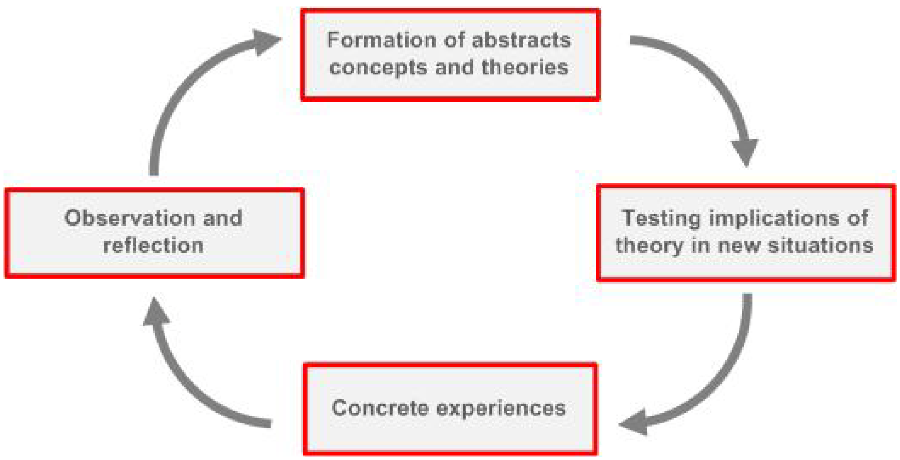


Figure 1: Schematic representation of Kolb’s learning cycle

Taking and passing the learning modules may stimulate the students’ interest in the topic and may give them an extra impulse to go abroad for a shorter period of time to one of the European project partner institutions. The participating institutions would thus welcome the exchange of students in addition to virtual mobility.

It was assumed that this VME-project should lead to the efficient application of distance learning and might not revert to traditional teaching. However, the project outcomes would mainly be based on existing learning materials. Eventually, the project outcomes would be integrated into the curriculum at the partner institutions, as each course module would represent a certain amount of ECTS credits (i.e. 3 or 5 ECTS credits as can be seen in the Figures 5, 11, 14). The student's workload would be set at approximately 25 hours per ECTS credit each.

The underlying methodology implies the following stages:

(1) reading and studying the learning materials,
(2) answering the questionnaires,
(3) feedback given by the tutor,
(4) getting access to the on-distance measurement set-up,
(5) validating the measurement by (instructed) reporting,
(6) final feedback and score given by the tutor,
(7) FAQ (questions, answers, hints, solution to problems) managed by the course instructor.

The "guidance" would be realised via the provisions of the common electronic learning platform (e-mail, forum), via the provisions of the learning modules, and via face-to-face discussions.

The assessment of the modules would be done via the results when answering the online tests/questions, and by taking a written exam or by writing a report.

The designed new learning materials would be tested and evaluated by both tutors/teachers and students not only of the own institutions but of the participating institutions as well.
The evaluation would be done by the involved staff at the project meetings and by intense contact via the electronic connectivity. The students would be asked to test and comment the designed learning materials by taking the modules, filling in the questionnaires, and by taking (part of) the designed modules on the spot at the various institutions.

A discussion at one of the project meetings resulted in the VME-questionnaire. The questionnaire used by the IUT/B1-partner was adapted to meet the requirements for the VME-project. Table 1 shows part of the questionnaire, as filled in by IUT/B1-students..

Lessons had been learnt from previous publications, EU projects and experiments, especially:

- on the needs of the target groups, on flexibility and learners' motivation [Scholze 2007],
- on the teacher's skills and knowledge, on the synchronous and asynchronous applications of the Internet [Olalla 2007; Jarmuskaite 2000],
- on the various aspects of the electronic learning platforms [Neto],
- on distance and online education [Mateo 2007],
- on digital inclusion [Casacuberta 2007].

So, in this Erasmus VME-project the four European partners have designed e-learning course modules for a higher educational context, emphasizing the added value of distance learning, mainly by stimulating students to carry out laboratory experiments and/or simulations. To be more specific, each partner institution has developed a learning module of laboratory practice in a specific domain. The modules are made available for the enrolled students on the electronic learning platform of the co-ordinating institution. Distance learning students can choose the developed learning modules at their home institutions and will be guided by tutors of the partner institutions.

The specialist fields in the VME modules are *physics, computer science* (DIT-Dublin/Ireland), *physical measurement, distance learning* (IUT/B1-Bordeaux/France), *electronics-ICT* (KHBO-Oostende/Belgium), *electrotechnics* and *environmental engineering* (TAMK-Tampere/Finland). Studying and experimenting with vacuum technology is offered by the School of Physics of DIT, measurements on basic electronic circuits are set up by IUT/B1, experiments with a Hall-element and a temperature-control system with a semiconductor device are offered by KHBO, and TAMK is guiding the students through some experiments related to environmental measurements and automation.

5. *The course module on Vacuum Science and Techniques for Nanoscience*

[3 or 5 ECTS credits]

Teachers involved at the Dublin Institute of Technology:

Fran Pedreschi [fran.pedreschi@dit.ie]
Catherine Grogan [catherine.grogan@dit.ie]

Introduction

Vacuum technology is an industrially common method of achieving clean environments for the production of materials that are sensitive to the presence of atmospheric contaminants. The nascent field of nanoscience and nanotechnology (the science of objects with length scales shorter than 100nm) is one of the largest projected growth areas for European economies for the next decade. Due to the nature of nano-sized materials, vacuum-based production techniques have been a natural choice for the production of many classes of materials, particularly semiconductor nanostructures.

The Vacuum Science and Techniques for Nanoscience module was therefore created to introduce students to vacuum science, plasma-based production techniques, and nanofabrication techniques used in nanoscience and elsewhere.

Course materials

In deciding on the content of the module, it was considered that nanoscience requires a broad range of knowledge from diverse fields. The course first introduces the fundamentals of vacuum technology and system design and then proceeds to look at a broad range of applications of vacuum technology for materials processing as well as related techniques which may not be vacuum based. Applications include introductory surface physics, materials analysis techniques including scanning probe microscopies, plasma technology in industry and chemical and physical growth techniques. Topical examples of structures are used wherever possible.

The overall aim of this module is to introduce the student to the concepts of vacuum technology and to a wide range of modern physical material production and analysis techniques, utilizing both well-developed and state of art approaches predominantly in a vacuum environment.

The full module has a total weight of 5 ECTS credits which can be broken down into several sections of different ECTS credit value, whereby the students can pick up the sections, depending on the total number of ECTS credits required by the students.
For the 3 ECTS credit option the students take Vacuum Science (2 ECTS credits), Surface Science and Surface Probe Microscopy (SPM), and the Low Energy Electron Diffraction (LEED) online experiment (1 ECTS credit). For the 5 ECTS credit option the students take Vacuum Science (2 ECTS credits), Surface Science and SPM, and the LEED online experiment (1 ECTS credit), Plasma Physics (1 ECTS credit), and Nanofabrication (1 ECTS credit).

The learning content and virtual experiment are both made available on the online learning platform Toledo.

The problem-based learning (PBL) strategy is used extensively in DIT, where the students learn while performing tasks or exercises under the guidance of a supervisor [Donnelly 2009]. Although this approach can put quite a high load on the student, it contextualises the material the student is learning, so they know why they need to know it during the learning process, not after, significantly improving recall. The implementation here can't be considered to be a full PBL-approach, but we have strived to implement, a "perform, reflect, and perform again if necessary" methodology.

Virtual experiment

Of particular importance to any technical course is the provision of experimental or laboratory experience. In this regard, vacuum science can be difficult due to the expense of the equipment required. The remote measurement concept of the VME project seeks to overcome this difficulty for distance learners by providing remote access to measurement equipment that may not otherwise be available. As vacuum science experiments usually take considerable time, and almost always require manual intervention, it was decided that the laboratory component of the module would be entirely virtual.

The component chosen for the virtual laboratory is a simulation of the Low Energy Electron Diffraction, or LEED, surface analysis technique. This uses an electron beam created by thermionic emission from a hot filament, typically with maximum beam energy on the order of 200 electron volts, to create a diffraction pattern of the constituent atoms or molecules in a crystal. Analysis of this pattern can lead to the deduction of the symmetry, periodicity and size of the crystal lattice structure. This technique requires ultra high vacuum to allow the electron beam to transit cleanly from the filament to the sample.

The Java environment was selected for the development of the virtual experiment, due to its wide and free availability. The simulator interface was designed to be as faithful to the interface of a real instrument as possible, so that a student should have a natural familiarity with any real instrument that they might encounter. In construction of the software, the physics components are implemented separately to facilitate the extension of the simulator to other vacuum techniques in the future.

The student runs the application within the learning platform, and conducts measurements after reading a pre-laboratory guide. The Guide contains additional information on a real LEED instrument, the operation of the controls and sample results. The simulator provides a surface whose structure, i.e. the symmetry and periodicity of the atomic arrangements, is randomly generated, within physically reasonable limits. The student must then determine these parameters from the diffraction patterns provided by the simulator. During the operation of the simulator, the student answers additional questions based on the observed pattern and on the changes in the pattern that occur when the student adjusts the controls, such as why does the spot intensity vary with beam energy, explain the relationship between bulk and surface spots, etc. These questions are generally essay type, with feedback. The student may then repeat the evaluation if necessary, after considering the feedback.

Module evaluation

Early stage evaluation of the module was carried out by 17 students (3 female, 14 male). This was done by making both the course material and the virtual experiment available online to registered members of the module. The evaluation consisted of multiple choice and paragraph-type questions that are filled in by students in a certain time limit in a supervised environment. Examples of these questions are shown in Figure 2.

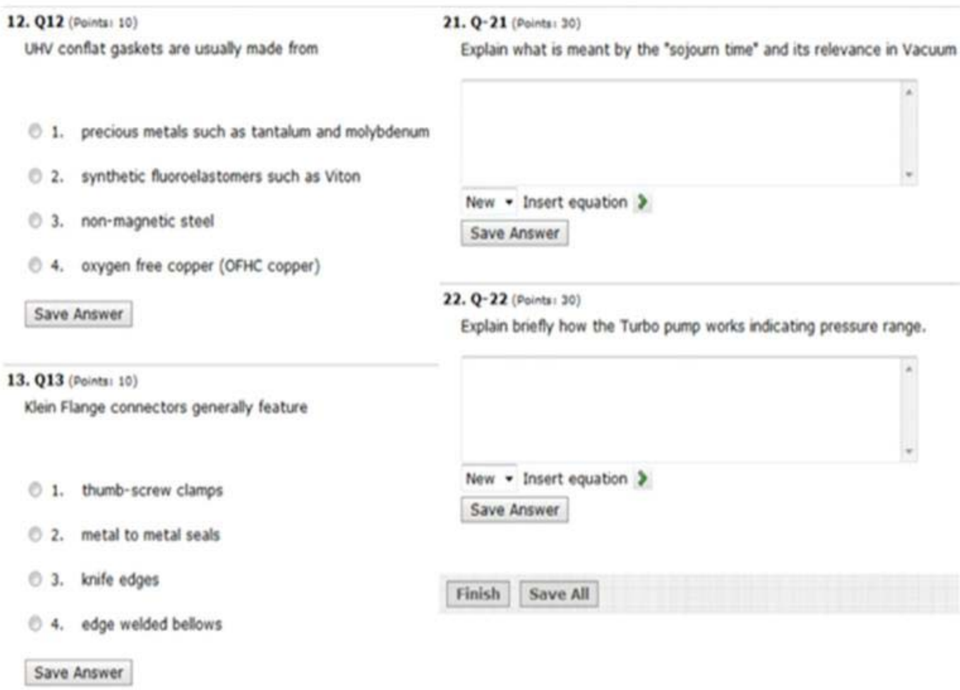


Figure 2: Example of multiple choice and paragraph-type questions from on-line evaluations

Evaluation of the virtual experiment

The virtual LEED experiment was evaluated by giving the students a list of pre-experiment questions based on the experiment. The questions are a mixture of multiple choice, calculation and hot-spot type. The students get feedback and can repeat the pre-test (see Figure 3).

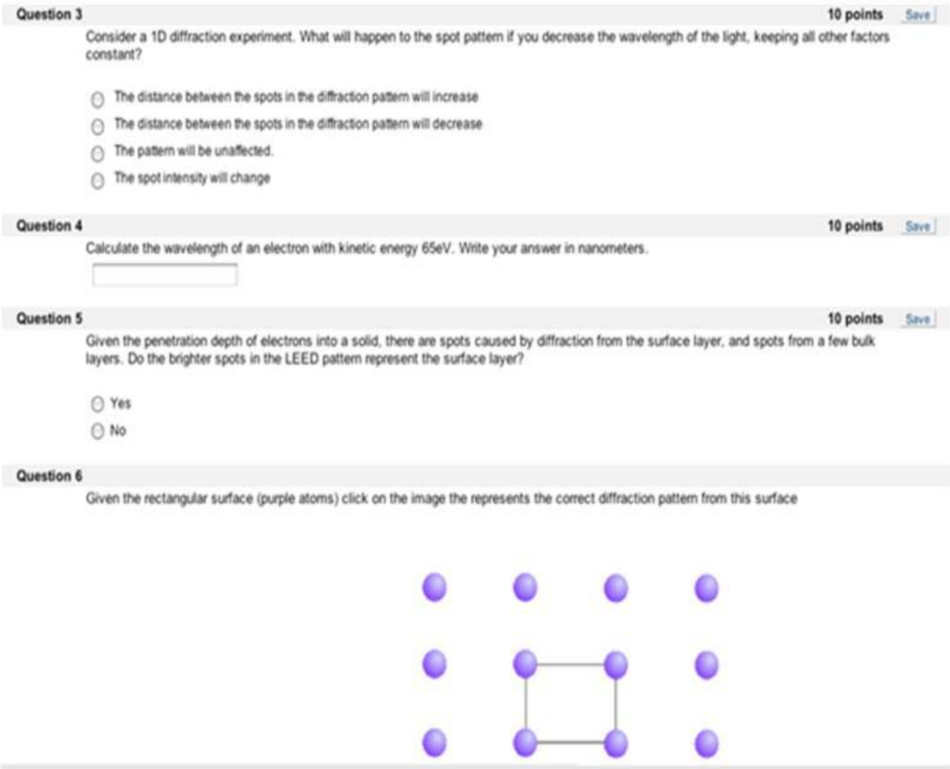


Figure 3: Pre-experiment test in the Toledo-learning platform

After successful completion of the pre-test, the student runs the simulator. At the same time, a series of essay type-questions are answered by the student, assessing their understanding of, and ability to extract information from, the diffraction pattern.

The next stage of the evaluation was carried out via distance testing by 5 KHBO-students (2 female, 3 male) in their third semester. In September-October 2009 the students tested the Toledo course module Techniques for Nanoscience. The third stage of testing was carried out by 5 incoming students from KHBO who travelled to the Dublin Institute of Technology and stayed there on 29-30 October 2009 to carry out two laboratory experiments, one on *Atomic Force Microscopy* (AFM for short), and the second on *semiconductor fabrication*.

The testing has resulted in suggestions for adaptations of the course module, such as adjustment of the detail level of the simulator, which was originally too complicated with respect to the course material, and more pre test documentation. By preparing a module in this manner, a reusable learning module has been created which can be made available to students wishing to study the module remotely.

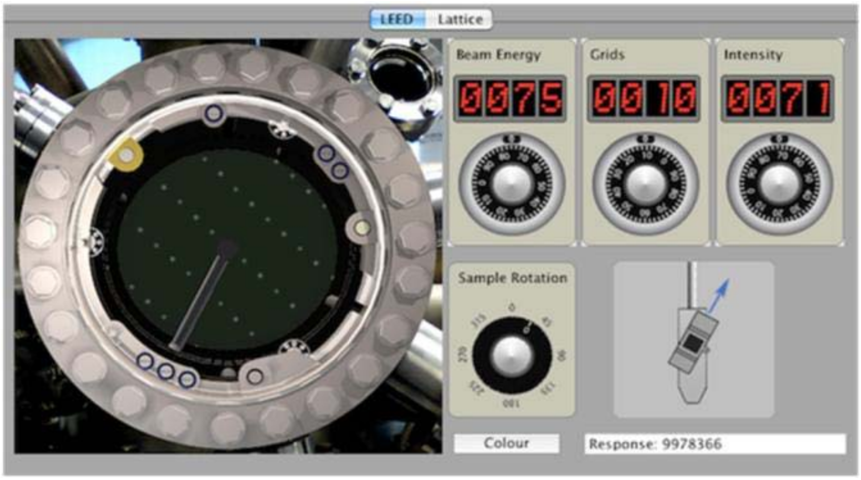


Figure 4: User interface of LEED simulator

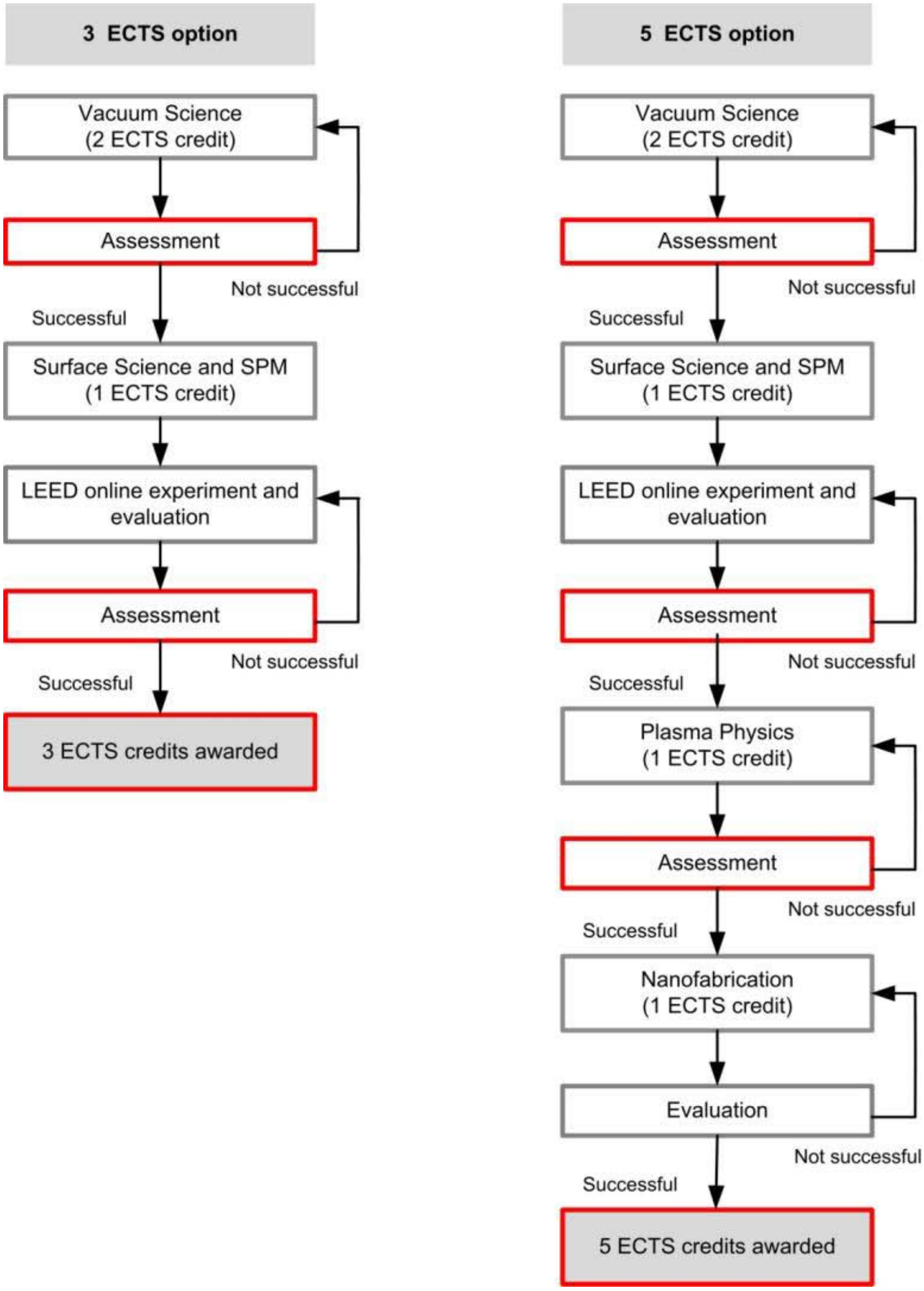


Figure 5: Flowchart of the organization of the course materials on Vacuum Science and Techniques for Nanoscience

6. The course module on Electronics of Devices and Circuits

[3 ECTS credits]

Teachers involved at the Université de Bordeaux 1, IUT :
Thomas Zimmer [thomas.zimmer@iut.u-bordeaux1.fr]
Sylvain Saïghi [sylvain.saighi@ims-bordeaux.fr]

Introduction

The VME project at IUT-Université de Bordeaux I has taken advantage of the educational opportunities presented by the www by combining a web-supported course management system offered by the Blackboard-Toledo platform and the on-distance facilities located at the University of Bordeaux 1. For this reason IUT-Bordeaux 1 put great effort in incorporating web-supported teaching in the course materials Electronics of Devices and Systems.

Course materials

The course module provides essential understanding of basic electronic concepts. The topics concern diodes and diode circuits such as rectifiers as well as basic transistor principles such as biasing, operating point, load line, small signal analysis and amplifier's quadrupole presentation bringing into play the input and output impedances, the transfer function and their interaction.

Course contents are made available online and are split up into 9 learning units. Each learning unit is organized into 3 parts. Theoretical concepts coupled with exercises are presented in the first part. An online laboratory session follows the theoretical investigation and provides a deeper understanding. Finally, an online assignment session for evaluation gives feedback to both the student and the teacher.

Pedagogical approaches

The course structure follows the learning-by-doing concept. At IUT it was the intention from the beginning not to simply offer web-supported learning, but also to combine it with a regular lecture format following the blended learning approach. Kolb's model, clearly describing the different phases of the learning process - as can be seen in Figure 1 - has been implemented in four steps: the first step "*Formation of abstracts, concepts and theories"* is performed through a regular lecture format (face-to-face session). Furthermore, the course content is made available on the learning management system Toledo, where students can revisit theoretical aspects, remake exercises already done during the lecture, deepen and reinforce the concepts of the course. The second step "*Testing implications of theory in new situations"* has been implemented using the Toledo platform. For this, the advanced evaluation facilities of Blackboard have been used. The types of questions include *Multiple Choice*, *True False*, *Fill in the Blank*, *Multiple Answer* and *Matching*. Figure 6 shows a screenshot of a typical exercise.

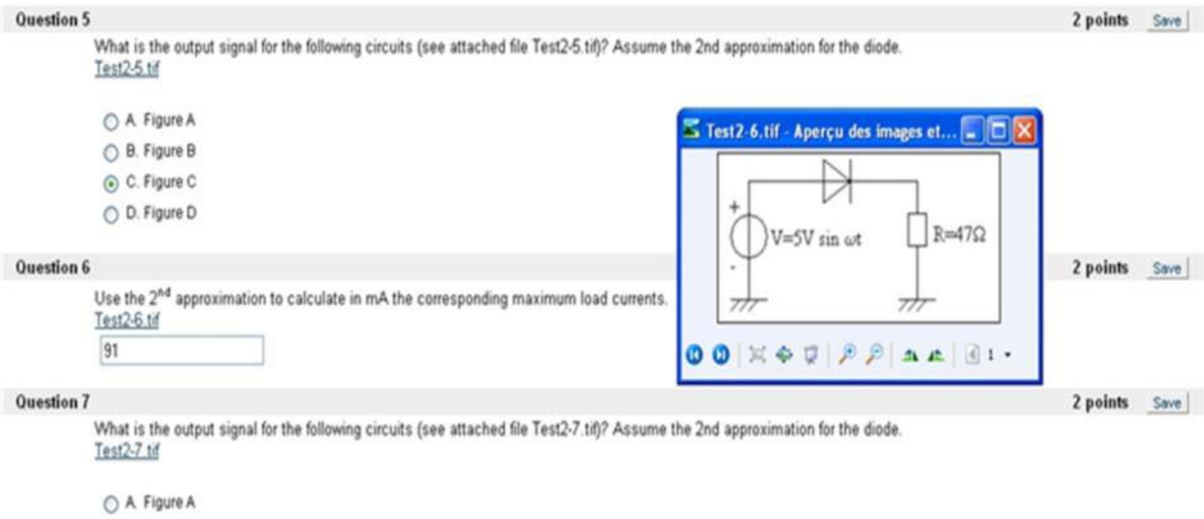


Figure 6: Screenshot of a Multiple Choice implementation

The third step "Concrete experience" is implemented in the learning cycle thanks to the on-distance measurement facility at the Université de Bordeaux 1 [reallab]. For each learning unit up to three different lab experiments have been realized and the students are asked to perform the measurements. Figure 7 shows an example: it illustrates the schematic presentation of the circuit to be measured and the related measurement interface.

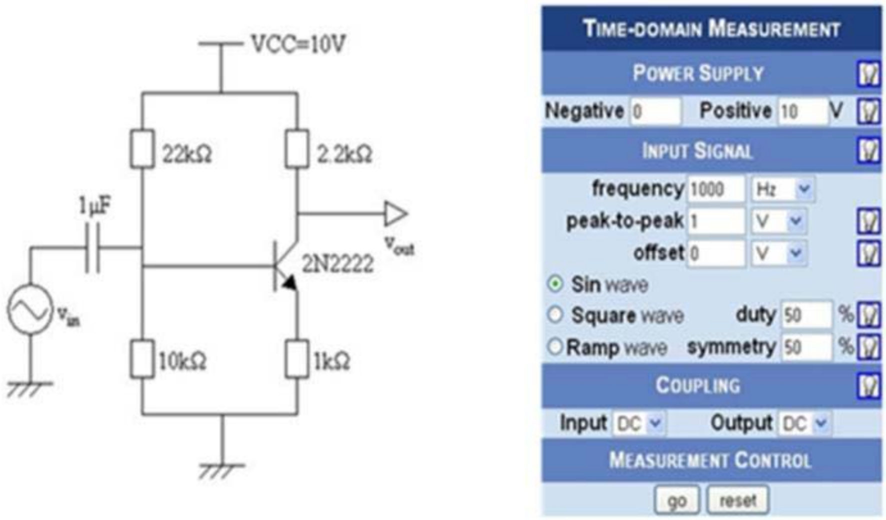


Figure 7: Schematic presentation of the circuit and measurement interface

The last step of Kolb's learning cycle "*Observation and Reflection*" is implemented again thanks to the on-distance measurement platform. After realizing the measurements on a given circuit, the student is requested to analyse the measured data. Figure 8 shows the measurement result of the circuit and stimuli from Figure 7.

An analysis of the measured data is done using the download possibility (see data, save date) or the enhanced graphical display where cursors are available making an investigation of the measured result very handy. It was also our intention to measure the effectiveness of the blended learning and its level of student acceptance as a teaching resource. In a previous study the on-distance measurement platform had already been evaluated [Lang 2007]. Questionnaires were used to obtain the students' views as to acceptance, usability, learning effect and usefulness in studying and vocational terms. The learning effect was also measured by a knowledge test. The results show that conducting experiments via the Internet is just as successful as conducting experiments in an actual laboratory. The experiments performed score well for usability and moderately for acceptance and usefulness.

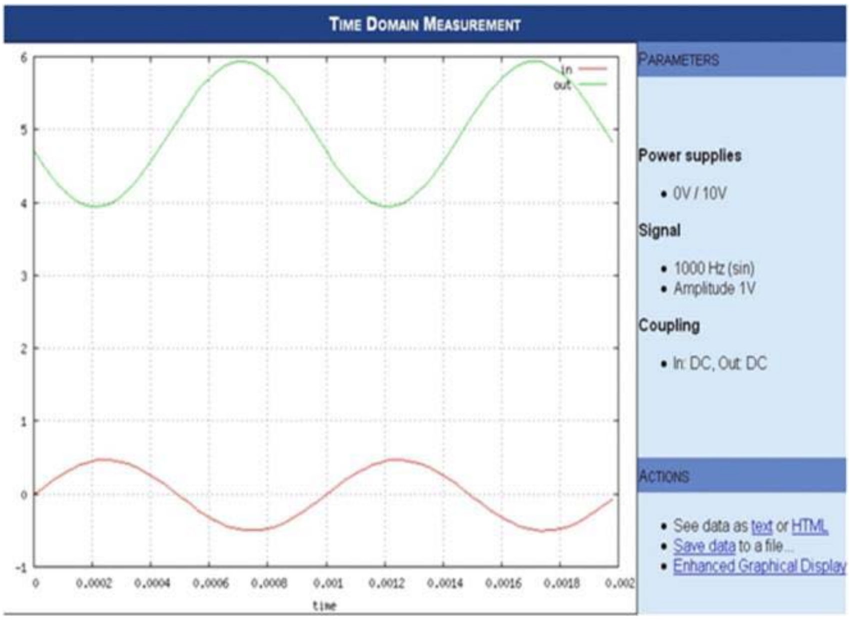


Figure 8: Measurement results

Module evaluation

An evaluation and testing of the implementation of the course module on the Toledo platform was carried out by 108 IUT/B1-students (24 female, 84 male, average age: 19 years). The courses ran from February till April 2009 with 22 hours of teaching/exercises, followed by 5 laboratory sessions of 4 hours each. The aim of the course was to give students knowledge of basic principles in electronics. Students were advised to use the VME Toledo platform after each session. There was only one test at the end of the course.

The students filled in a questionnaire [QST], covering 5 themes: (1) acceptance of learning via the platform; (2) English language skills: all the texts and information, explanations and instructions on the Toledo platform are in English; 3) usability of the VME platform; (4) usefulness of the VME platform; and (5) self-evaluation learning effect: memory, comprehension and application of the material.
Some results of the questionnaire at the IUT, Bordeaux 1 can be seen in Table 1.

Results Questionnaire for students taking the VME *Module: Electronic devices and circuits (IUT)*

Date: 3-4 May 2010 - 1st Year students Professional Bachelor in Electromechanics

Questionnaire has been filled in by 23 male students: Age: 18 years (34,8%) - 19 years (30,4%) - 20 years (26,1%) - 21 years (8,7%)

Scores of the statements on a scale from 1 (I totally refuse) to 6 (I completely agree).

No.	Statement	Score
1	The English texts are easy to understand.	3,83
2	I am able to start a discussion about the topics of the VME in English	3,57
3	I have some difficulties with the vocabulary used in the VME.	3,04
4	Compared to my fellow students, my English isn't that good.	2,61
5	The English texts are difficult to understand.	2,87
6	Computers confuse me.	2,48
7	Even when I think of using a computer, I feel bad.	1,87
8	Working on the computer disturbs me.	2,17
9	I would wish that other practical courses were put online.	3,04
10	I would do this course again.	3,57
11	I prefer learning in the VME compared to learning with textbooks	2,39
12	If there is a choice between web-based learning and learning with textbooks I will prefer	4,48
13	I enjoyed using the VME.	3,39
14	It's much better to see the experiments in reality than in the VME.	5,26
15	I would recommend a fellow student to take this course, too.	3,35
16	The VME motivated me to learn more about the topic.	2,43
17	The fact of being in a PC-room instead of a physical lab disturbs me.	3,52
18	Much effort is required to learn how to use the VME.	3,22
19	Navigating in the VME was confusing for me.	2,78
20	I would like to have a preliminary course for using each instrument.	3,00
21	The instruction to make use of the VME is sufficient.	3,09
22	I always knew how to navigate through the VME.	2,61
23	The handling of the experiments (measures) is easy for me.	3,39
24	The VME is a good preparation for my exams.	3,57
25	For my studies it was helpful to take this course.	3,48
26	The VME is a good preparation for my future job.	2,39
27	Being in the VME was a waste of time.	3,09
28	Taking the course was the right step to achieve my professional goals.	2,61
29	Making remote measurements adds a "European dimension" to the practical course.	3,74

The students were able:

to memorise	62	% of the topics
to understand	74	% of the topics
to apply	63	% of the stuff to similar problems

Would you like to get in touch with the person in charge of instruments abroad?

No (87%) - Yes (13%), because of translation problems.

Which communication medium do you prefer for learning procedures?

Chat (30,4%) - Email (26,1%) - Telephone (4,4%) - Videoconference (39,1%)

Suggestions for improvement of the VME:

1. It would be useful to put the picture of the measurement circuit available next to the measurement results (oscilloscope screenshots).
2. Even if the answer is correct (test), it would be useful to explain the correct solution, because it could have been a lucky venture.

Table 1: Results of the VME questionnaire for the IUT/B1-module

A second and external testing and evaluation was carried out by 4 first year KHBO-students. The students used the Toledo learning platform and tested three chapters of the IUT-course module (chapter 3: the bipolar transistor basics; chapter 4: transistor operating point and load line; chapter 5: transistor biasing circuits). The course ran from 23 November till 4 December 2009, and the time needed to finish the course chapters was respectively 56 minutes (chapter 3), 46 minutes (chapter 4) and 56 minutes (chapter 5). The students filled in the same VME questionnaire as the IUT-students had filled in.

The testings at IUT/B1 and KHBO have resulted in suggestions for adaptations of the course modules (as can be seen from Table 1: Results of the questionnaire on strengths and weaknesses of the electronic learning platform).

7. The course module on the Measurement of the Hall Effect

[3 or 5 ECTS credits]

Teachers involved at the Katholieke Hogeschool Brugge-Oostende:
Iris Vandecasteele [iris.vandecasteele@khbo.be]
Jan Poelaert [jan.poelaert@khbo.be]

Introduction

The KHBO has developed two modules that are related to the domain of physics and electronics, and useful for the basic training of students in applied sciences, technology and engineering sciences. The first module aims to give the students a basic insight in the electromagnetic behaviour of a semiconductor as a Hall element, and to provide them with some practical experience with measuring physical quantities. The structure of this module also accentuates the student's critical attitude towards the accuracy of a measurement set-up. The second module builds on the acquired knowledge on measurement accuracy and graphical programming of the first module. It aims to give the student a basic insight in the thermal behaviour of a heat sink. Finally, in the second module the students are instructed how to define and test a temperature control system.
For both modules, students are explained how to apply some basic techniques of graphical programming, respectively for simulation and for controlling the laboratory set-up. For both modules the measurement set-up is available via the internet.

The Hall effect laboratory session (3 ECTS credits)

The course module will enlarge the student's knowledge of the properties of semiconductors such as mobility and concentration of charge carriers, resistivity and conductivity, extrinsic and intrinsic

conduction. The Hall-effect of a semiconductor is the physical phenomenon that can be measured and evaluated via an on-distance measurement set-up.
Both N and P rectangular samples of germanium can be measured as a function of a control current and a magnetic field. The students can carry out several simple experiments, by accessing the measurement set-up via the internet. The measured data can be captured and visualized on their personal computer.
Figure 9 shows the original automated laboratory set-up and a diagram illustrating the Hall effect on a semiconductor. As the students seem to prefer a real view on the measurement set-up, a webcam could be installed to give them a idea of the on-distance measurement.

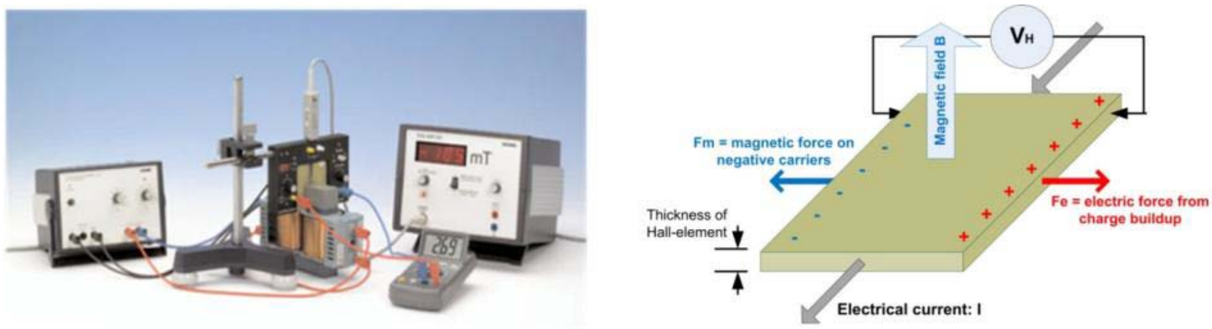
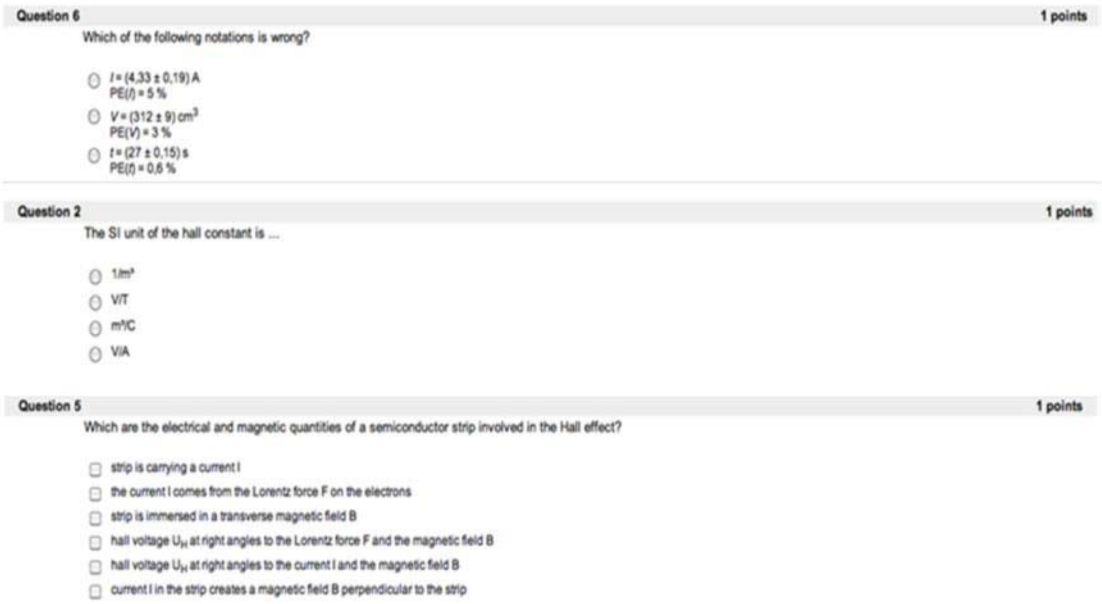


Figure 9: Picture of the original laboratory set-up and diagram of Hall-effect principle

The content of the Hall effect laboratory session

The students who start the Hall effect laboratory session and carry out the experiment are supposed to possess a basic knowledge of electricity and electronics. The students are told how to get acquainted with the Hall-effect of a semiconductor. They are also instructed to gain basic knowledge on the application of a graphical programming language in order to process the measurement results.

The course module is structured as a sequence of chapters, covering:
(1) some semiconductor theory;
(2) an analysis of the measurement set-up;
(3) the handling of measurement errors;
(4) basic techniques of graphical programming.



Question 6 — 1 points

Which of the following notations is wrong?

- $I = (4{,}33 \pm 0{,}19)$ A
  PE(I) = 5 %
- $V = (312 \pm 9)$ cm³
  PE(V) = 3 %
- $t = (27 \pm 0{,}15)$ s
  PE(t) = 0,6 %

Question 2 — 1 points

The SI unit of the hall constant is ...

- 1/m³
- V/T
- m³/C
- V/A

Question 5 — 1 points

Which are the electrical and magnetic quantities of a semiconductor strip involved in the Hall effect?

- strip is carrying a current I
- the current I comes from the Lorentz force F on the electrons
- strip is immersed in a transverse magnetic field B
- hall voltage U_H at right angles to the Lorentz force F and the magnetic field B
- hall voltage U_H at right angles to the current I and the magnetic field B
- current I in the strip creates a magnetic field B perpendicular to the strip

Figure 10: Screenshot of Multiple Choice questions on Hall effect module

By carrying out the on-distance measurement, the student will collect data which reveal the relationship between the electrical current and magnetic field through a semiconductor, and the resulting Hall-voltage.
The student can determine the hole concentration in the P-Germanium and the negative electron concentration in the N-Germanium samples. A critical analysis of the accuracy of the measured Hall-voltage and of the calculated concentrations may result in a validation of the measurement. The student can finish off the laboratory session on the Hall-effect by posting the final report to the instructor (see Figure 11).

Temperature control session (2 ECTS credits)

This module will enlarge the student's knowledge on the thermal behaviour of semiconductor devices and heat sinks. The student will learn more about control systems (open loop and closed loop behaviour). He is instructed how to become more familiar with the use of a graphical programming language by building a Virtual Instrument (VI). This experiment also emphasizes the processing of measurement errors, leading to a critical view on measurement accuracy. Students who passed the module on the Hall effect can then take this course module on temperature control.
The measurement set-up is built up of a thermal generator (power semiconductor), its drive circuit and a temperature measurement circuit. The whole set-up is connected to a server, which is also connected to the internet. While observing the behaviour of the heat-sink, the students can load and run their VI-design on this server.

The content of the temperature control session

First, the student needs to get acquainted with the theory of heat dissipation, thermal resistance and thermal capacitance. At the end, every student has to programme his own temperature control system, using a graphical programming language. The course module is structured as a sequence of chapters, as can be seen in Figure 11):

(1) a study of the temperature measurement circuit,
(2) an assignment on the design of a Virtual Instrument (VI)
(3) a study of the meaning of thermal resistance and thermal capacitance giving insight in the behaviour of heat sinks,
(4) a study of the drive circuit for the thermal generator of the heat sink,
(5) a guide to design VI's in order to measure the temperature and drive the thermal generator,
(6) a study of the behaviour of closed loop systems and the use of controllers,
(7) a tutorial to design and apply virtual P and PI controllers,
(8) a guide to test the behaviour of the closed loop system and to write the final report.

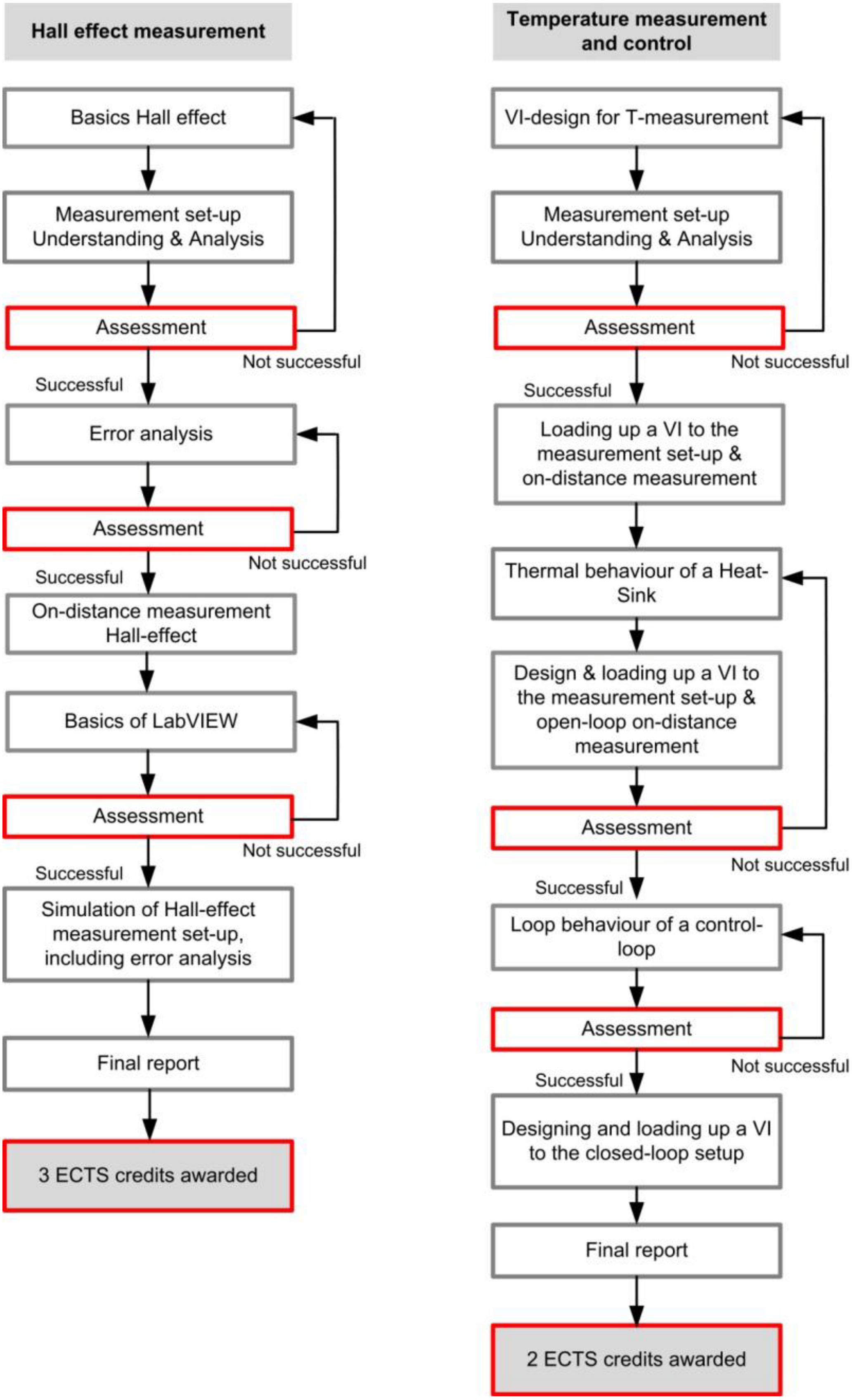


Figure 11: The structure of the Hall effect and Temperature module

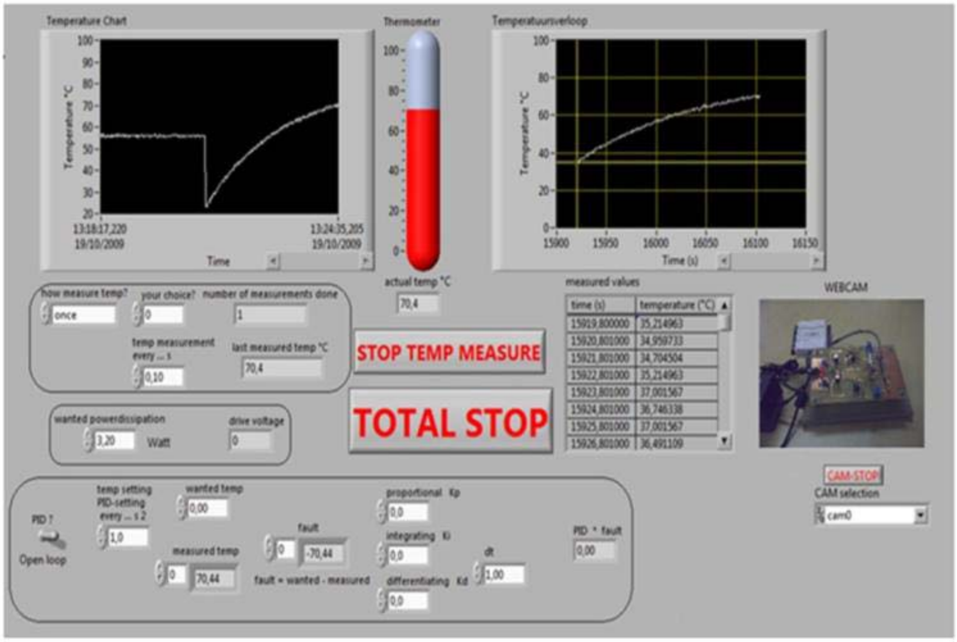


Figure 12: Example of front panel lay-out of the electronic temperature measurement

Pedagogical aspects of the laboratory sessions

The use of a graphical programming language, the world-wide-network and remotely available laboratory equipment allows to perform real but on-distance laboratory sessions. The laboratory equipment is unmanned and students are not restricted by a time constraint to carry out this experiment.

The remotely available laboratory also contains a webcam**,** and images of this webcam (see Figure 12 for a front-panel view and Figure 13 for the diagram of the related Virtual Instrument for the webcam) are sent to the student's PC (this is the case for both the Hall effect laboratory session and the temperature control laboratory session). As a result of an oral evaluation by students in applied engineering at KHBO-BE the connection of a webcam to the measurement set-up was realized.

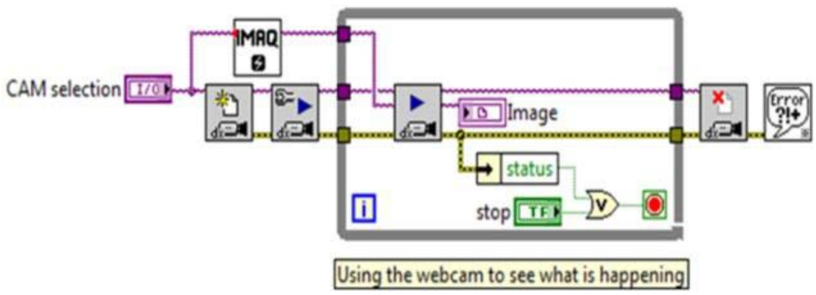


Figure 13: block diagram of a set-up and the LabVIEW program for the webcam control

Module evaluation

An evaluation of the chapters on graphical programming within the Hall effect module was carried out internally by 5 first year KHBO-students. The course chapter ran from 14 September till 11 December 2009. Going through the evaluation tasks took the students 20 minutes. The laboratory session on temperature control, still in its development phase, was taken and evaluated by an incoming IUT/B1-student.

8. *The course module on Monitoring of Environment and Industrial Drive Systems*

[3 or 5 ECTS credits]

Teachers involved at the Tampereen Ammattikorkeakoulu:
Jarmo Lilja [jarmo.lilja@tamk.fi]
Mikko Vaarala [mikko.vaarala@tamk.fi]
Pasi Arvela [pasi.arvela@tamk.fi]

Introduction

The course module Monitoring of Environment and Industrial Drive Systems consists of basic sensor and automation technology applied to the monitoring of environment and industrial drive systems.
In the common initial part of the course the student will learn the basics of the graphical programming language. In the second part the student makes his choice: he studies in-depth and develops a virtual instrument for the monitoring of environment or for the controlling of an industrial drive system. In Monitoring of Environment the student will learn the basics of the data acquisition (DAQ) sensor programming. Temperature, pressure and relative humidity sensors are the most commonly used in the environmental area. In Industrial Drive Systems a wireless remote controlled Lego robot is used for training the student's programming skills. Finally, for both options the student will apply his programming skills to real life problems.

Course structure

Figure 14 shows the module with the awarded ECTS credits. The module consists of three parts:

(1) Introductory part: the basics of programming techniques including device programming (2ECTS credits).
(2) Monitoring of Environment (3 ECTS credits).
(3) Controlling and programming of a drive system (3 ECTS credits).

The student is awarded 5 ECTS credits by taking *either* part 1 + part 2 *or* part 1 + part 3.

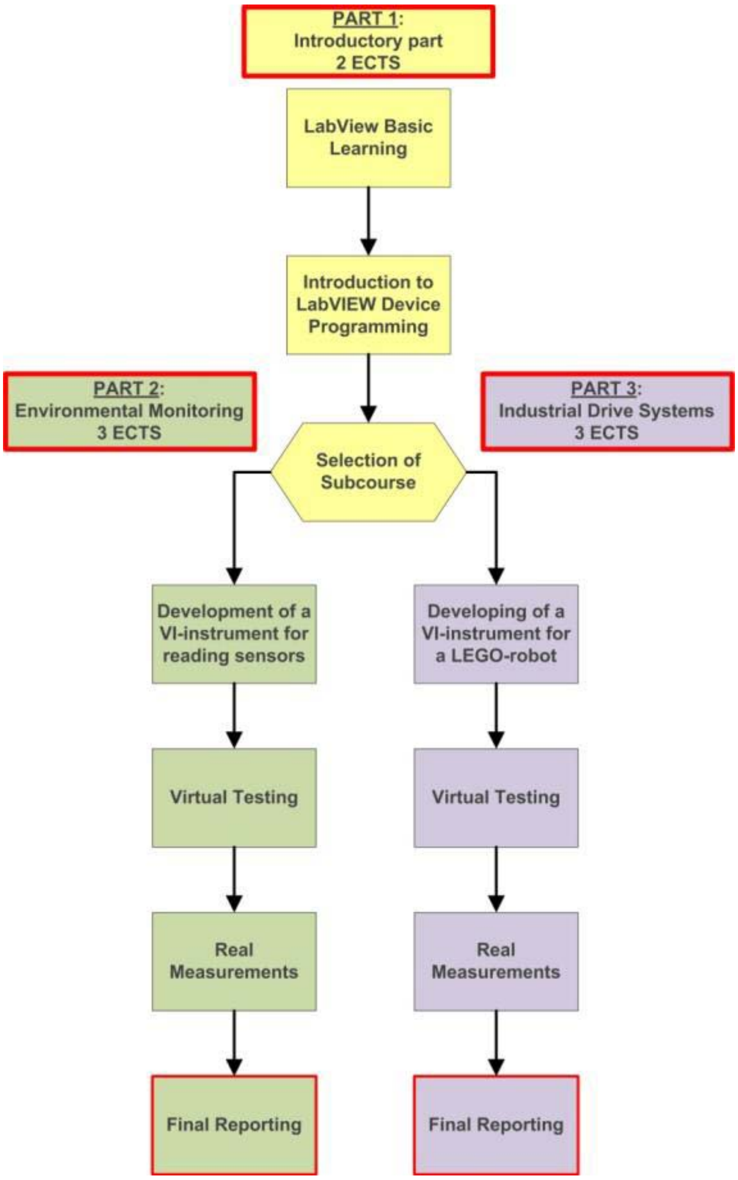


Figure 14: Structure of the course module on monitoring of Environment and Industrial Drive Systems

The student is supposed to carry out the preparatory tasks as well as the practical exercises and experiments in his home university, where he disposes of the sensors or the Lego robot. The TAMK-tutor guides the student via the electronic learning platform Toledo (as shown in Figure 15).

Module evaluation

In 2008-2009 the first tests of the module were carried out at TAMK by 19 students, coming from the own institution or from France (IUT/B1) and Spain (Universitat Politecnica de Catalunya. The programming of Vernier DAQ sensors in Monitoring of environment and remote controlled lego robot in Monitoring of industrial drive systems were reported by 7 students.

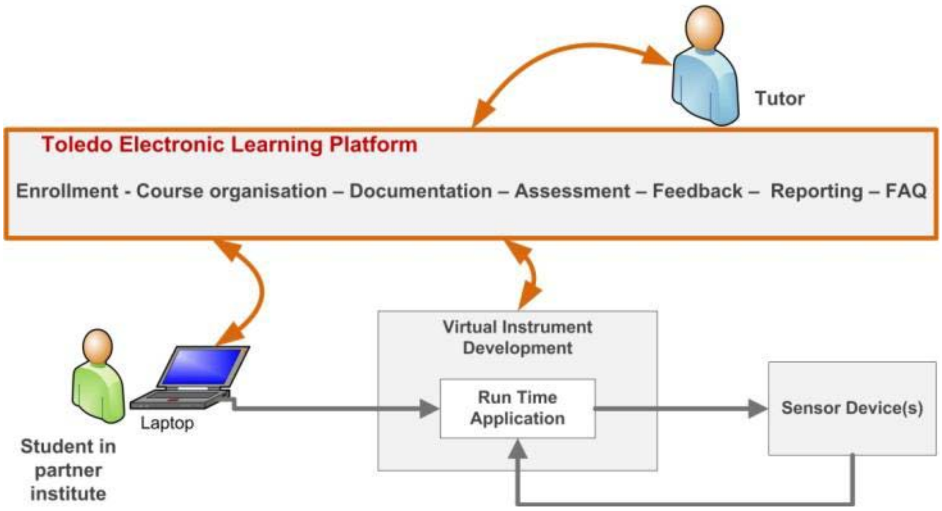


Figure 15: Communication for the Course Module on Environment and Industrial Drive Systems

9. Project guidelines and results of the questionnaires

Guidelines for students

The guidelines for the students are the same for all the members of the consortium who want to enroll in the VME project. The sequence of the steps is illustrated in Figure 16.

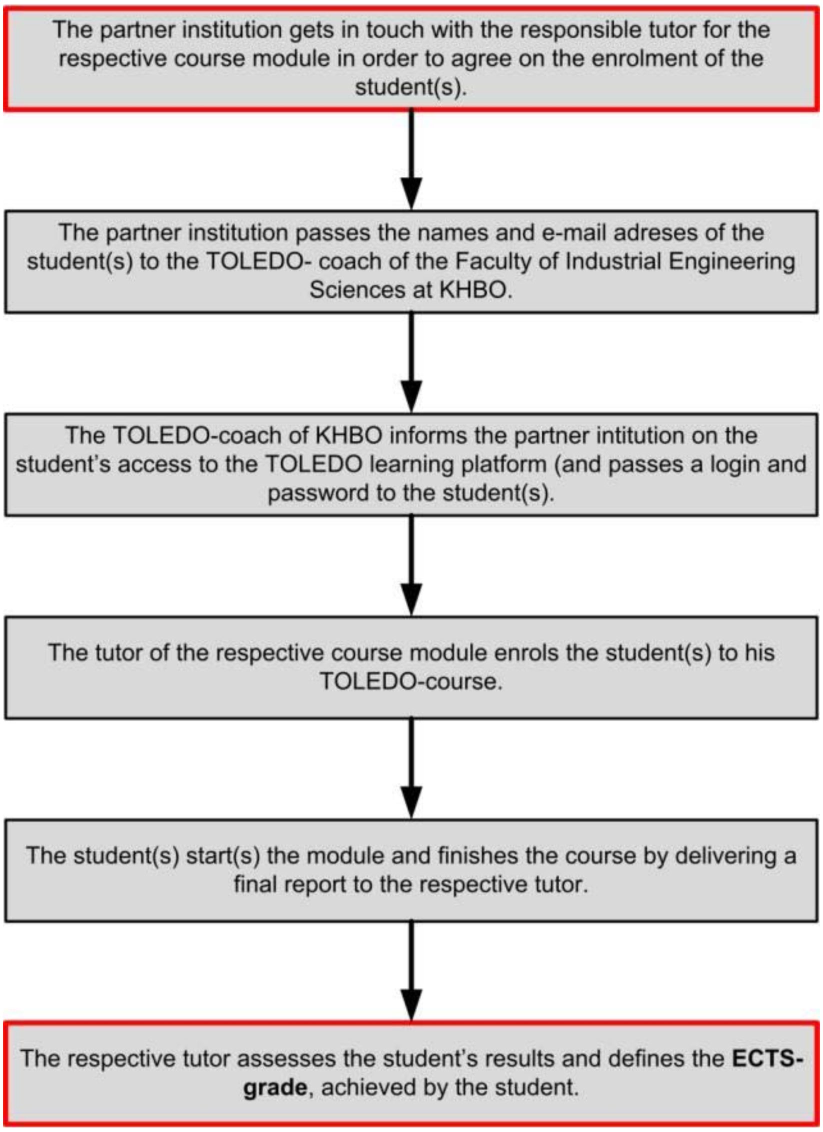


Figure 16: Sequence of steps for enrolment of students

Results of the questionnaires

The testings at the four project partner institutions have resulted in suggestions for minor adaptations of the course modules. Inspiring for the course developers are some of the students' outspoken reactions in the VME questionnaires. According to the students the electronic learning platform shows striking strong and weak sides. The strengths and weaknesses are summarised in the table 2:

Strengths of the electronic learning platform	Weaknesses of the electronic learning platform
1. Even without so many English language skills, VME helps me to improve my English. 2. The English language: our study gets an European dimension. 3. Accessible from everywhere. 4. The presentation of the course in 3 steps. 5. The fact that the course/exercise/lab sessions are in the same format. 6. Easy-to-use. 7. The lessons are well-built and the	1. The English language.I would better understand the course if the English were French.[*] 2. There is no page with technical translation. 3. Sometimes the vocabulary is difficult to understand. 4. I need dictionary to understand. 5. The use of a computer. 6. I don't have a computer at home. 7. Not useful for people who don't like to work on a computer.

explanations are helpful. 8. The exercises are well-done to test the comprehension. 9. Lots of exercises. 10. The correction of the exercises. 11. The tests are good. 12. The exercises and corrections are clear. 13. The quality of the questions: not too easy/ not too difficult. 14. A good preparation for my future job and exams.	8. Working with computer is more difficult compared to working with a textbook. 9. Pdf files for courses are not so good. 10. There is not enough explanations when the answer is wrong. 11. Too many tests. 12. Not enough calculation in the tests.

[*] this reaction only at IUT/FR and TAMK-FI

Table 2: Strengths and weaknesses of the electronic learning platform

10. Conclusions

The project objectives and outcomes

The four modules, covering four different technical domains, have been designed and developed according to the objectives and learning principles that had been put first at the start of the project. They are now operational and made available for the consortium to be integrated into their curricula, applying the European Credits Transfer System (ECTS). The project outcomes have been tested internally both by teachers and students, not only at the own but also at the partners institutions.

The *blended PBL approach* has demonstrated to have some potential advantages. It has stimulated the team spirit within the group of the course designers and tutors, giving them a better technological and pedagogical insight. During the development and realization period of the four different workpackages, the intense collaboration among the project partners on distance and e-learning has resulted in some informing experiences: for the participating teachers and tutors the (sometimes slightly) different pedagogical approaches have led to a critical reflection on their own pedagogy and didactics. A similar phenomenon could be observed from the students' perspective: the learners were strongly motivated, and had the feeling of being intensely involved in the learning process. The transformal potential of blended learning has proved to be effective. The learning by doing approach has turned out to be quite successful.

The VME project makes use of a learning path, in which the various tests are stepping stones in the student's progress or remediation. For the editing of the tests a number of question types can be used, of which most can use automatic score so that students can walk along the learning path without intervention of the instructor. Although the range of the test typology of Toledo is not very vast, it enables multimedia realisations. There are 17 question types, of which the most frequent types are *multiple choice question*, *true or false*, *multiple answer*, *matching* and *fill in the blanks***.** The instructor can at all times control the student's progress and - if necessary - guide him/her through personal Internet communication.

The use of ***an electronic learning platform*** could show some outstanding positive aspects. Firstly, the electronic connectivity has led to a lively teacher/student and student/student communication. A second positive aspect was the student's enthusiasm, mainly because of the involvement in the flexible learning process. In this respect can be concluded that the VME questionnaire was extremely useful. Thirdly, the student has to be more attentive while doing the laboratory tasks and experiments. He cannot rely on the work of other students - as is often the case in the traditional laboratory environment. He is forced to do the work or to answer the questions himself. A further conclusion is that the individualised approach may make the learning easier for the student. A final advantage of the use of the platform is that the student can go beyond the boundaries of his/her own institution. The virtual mobility makes the contact with the 'outside world' a reality.

In the VME project it was decided upon the use of **one single and common electronic learning platform,** Toledo. The participating institutions, however, all have their own electronic learning platforms. That means that different servers have to be connected so that laboratory experiments on the different locations can be accessed from the home location. Because of the importance of the problem the VME consortium has decided to deal in-depth with the pros and cons of the use of the common electronic learning platform. What if the students and teachers involved in the dissemination of EU lifelong learning project outcomes have to master three or four different learning platforms ?

All in all, the consortium assumed that there were some advantages:
- The four developed modules are embedded in the same electronic environment, and make thus a coherent package.
- The course designers are forced to apply and implement the same pedagogical model. This leads to an easier exchange of ideas and experiments.
- The use of the common platform makes it easier to control and manage.

On the other hand, there are some disadvantages as well:
- One institution is saddled with all the administrative fuss.
- The enrollment of the students always takes a detour.
- The enrolled students have to be made familiar with the new platform.

Additional remarks can be made:
- An additional advantage for the enrolled student might be that he has become more prudent, more critical and more attentive as for the guidelines and instructions not only when writing a final report to his foreign teacher/tutor, but also when communicating with foreign fellow students and teachers.
- It turned out that the course designers after all give preference to maintain a written final test or examination. Most of them still believe that this is the most reliable way of evaluating the student.
- The student's engagement and enthusiasm may be illustrated by a remarkable action: some of the evaluation stages of the DIT-module on *Techniques for Nanoscience* was carried out by 5 KHBO-students via the learning platform. The following stage of testing was done by the same KHBO-students who travelled to the Dublin Institute of Technology to carry out on the spot two laboratory experiments.
- There is the dire need of an adequate infrastructure when using an electronic platform: some technical aspects should be taken into consideration, for instance the security of the network, the co-operation of the IT manager towards the enrollment of the foreign students.
- Finally, both teachers and students came to the conclusion that an introductory face-to-face session with teachers/tutors and other students should be organized, to make students familiar with the learning environment, laboratory instruments and learning materials. This could be done through a previously agreed videoconference.

However, to overcome some of the technical and pedagogical problems the support and collaboration of qualified staff members is necessary. But academic teachers are not always well-instructed on the use of advanced ICT tools and on the pedagogical strategies that are typical of evolved distance learning and e-learning [Lionarakis 2008]. All this requires among other permanent in-service training/refresher courses of the academic staff, the essential infrastructure at the university, and a strict and binding course planning [Priem 2009, 143].

The analysis of the questionnaires filled in by the students at the VME project partner institutions has made it clear that there is the urgent need of a good command of spoken and written English for both teachers and students.

11. References

[Casacuberta 2007] David Casacuberta (2007): *Digital Inclusion: Best practices from eLearning.* eLearning Papers, no. 3. ISSN 1887-1542.

[Curran 2004] Chris Curran (2004): *Strategies for e-Learning in Universities*. Berkeley: University of California, Research & Occasional Paper Series: CSHE.7.04.

[Donnelly 2009] Roisin Donnelly (2009): *The nexus of problem-based learning and learning technology: does it enable transformative practice?*

[EUA] European Commission: *European Universities implementing Bologna*.

[EUA] European Commission: *Universities Shaping the European Higher Education Area*.

[Jarmuskaite 2000] Lina Jarmuskaite, Regina Kulvietiene, Irma Sileikiene (2000): *Comparison of asynchronous and synchronous learning tools.*

[Kolb 1984] D. Kolb (1984): *Experimental Learning: Experience as the source of Learning and Development*. Toronto: Prentice Hall.

[Lang 2007] D. Lang, C. Mengelkamp, R.S. Jäger, D. Geoffroy, M. Billaud and T. Zimmer: *Pedagogical evaluation of remote laboratories in eMerge projects*. European Journal of Engineering Education, 32 (1), 57-72.

[LC 2004] European ODL Liaison Committee (2004): *Distance learning and eLearning in European Policy and Practice.*

[LC 2006] European ODL Liaison Committee (2006): *Learning Innovation for the Advanced Lisbon Agenda*.

[Lionarakis 2008] Antonis Lionarakis (2008): *The theory of distance education and its complexity*.

[Mateo 2007] Joan Mateo, Albert Sangrà (2007): *Designing online learning assessment through alternative approaches: facing the concerns.* www.eurodl.org/?keyword=distance%20education&article=294.

[Mezirow 1975] J. Mezirow (1975): *Education for Perspective Transformation: Women's Reentry Programs in Community Colleges.* New York: Center for Adult Education, Teachers College, Columbia University.

[Mezirow 1995] J. Mezirow (1995): *Transformation Theory of Adult Learning*. In: M.R. Welton (ed.): *In Defense of the Lifeworld.* New York: Sunny Press, 39-70.

[Neto 2007] Pedro Leão Neto, Margarida Amaral (2007): *CAAD and e-learning: a blended approach.* eLearning Papers, no. 3. ISSN 1887-1542.

[Olalla 2007] Antonia Andrade Olalla (2007): *Blended learning as a proposal for European convergence in the teaching of natural sciences*. eLearning Papers, no. 3. ISSN 1887-1542.

[Priem 2009] Freddy Priem, Johan Calu, Renaat De Craemer (2009): *Towards the Integration of Course Modules of Different European Institutions of Higher Education into a Multimedia Learning Platform*. Annual Journal of Electronics of the Technical University of Sofia, 3 (2), 141-143.

[QST] VME Questionnaire. See http://www.khbo.be/vme

[Reallab] http://www.real-lab.org

[Scholze 2007] Tim Scholze, Sabine Wiemann (2007): *Successful Blended Learning Projects in 2006: Experiences in different formal, non-formal and informal learning environments.* eLearning Papers, no. 3. ISSN 1887-1542.

[Szucs 2009] Andras Szucs (2009): *New Horizons for Higher Education through e-Learning*.

[Toledo] http://www.khbo.be

[VME] http://www.khbo.be/vme